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ABSTRACT

This study investigated the question of hemoconcentration-hemodilution and subsequent vascular fluid shifts evidenced by marathon runners. Blood samples were taken from runners before and after the New York City Marathon of 1978 and the Fiesta Bowl Marathon of the same year. Participants were of both sexes. Tables accompanying this report present information on the characteristics of the subject groups, hematological changes elicited by marathon running, serum electrolytes and osmolality following a marathon, and percentage changes in volumes of blood, plasma, and red cells following a marathon race. (JD)

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HEMATOLOGICAL CHANGES FOLLOWING A MARATHON RACE IN MALES AND FEMALES

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With prolonged exercise without fluid replacement, it is generally accepted that dehydration occurs and that plasma volume decreases. However, little is known about these variables when fluids are consumed by athletes who are well trained.

Before other blood borne indices can be examined, the question of hemoconcentration-hemodilution and subsequent vascular fluid shifts must be understood. For this purpose blood was obtained from the anticubital vein immediately after, and 4, 8, and 24 hours after the completion of a competitive marathon event. "Control" blood was obtained one week prior to the race at the expected finishing time to account for diurnal variation. No attempt was made to control or measure the fluids consumed during the race other than to verbally encourage the subjects to drink "as you usually do." Water and ERG was provided at 5 mile intervals by race management.

Blood analysis was accomplished using an SMA 12/60 Technicon AutoAnalyzer, a Fisk osmometer (in NY), an Advanced Osmometer (in PHX), and a Coulter Counter. Our statistical approach utilized ANOVA with respected measures with post-hoc analyses using the Scheffé Multiple Comparison technique. Linear trend analysis was also performed.

Three groups of subjects participated in the study. One group consisted of 10 male runners participating in the 1978 New York City Marathon (NY MALES). Mean age was 34.5 years and mean training distance run was 61 miles per week. The average finishing time for this group was 240 minutes. A second group of 6 male runners participated in the Fiesta Bowl Marathon (PHX MALES) of 1978 (Scottsdale, Arizona). Mean age was 30.0 years, and mean training distance run was 72 miles per week. The average finishing time for this group was 199 minutes. These runners were more experienced than the NY MALES. The third group of subjects were 4 female runners participating in the Fiesta Bowl Marathon

of 1978 (PHX FEMALES). Mean age was 28 years and mean training distance run was 81 miles per week. Average finishing time was 178.8 minutes. These women placed 2nd, 4th, 5th, and 8th in the women's senior class. Table 1 presents a summary of the characteristics of the three subject groups.

Table 1 about here

The two marathon events differed considerably. The NY race was hilly. Air temperature at the start was 10 C, RH 80%. The temperature warmed to 22 C at the finish, while the RH decreased to 53%. In Phoenix, the race course was flatter. Air temperature was 10.6 C at the start and 15 C at the finish. RH was 67% at the start falling to 48% at the finish.

Results and Discussion

The hematological status of the runners is presented in Table 2. No significant differences were observed in either group of male subjects in Hb, HCT, or RBCs. With the exception of three mean HCT values, all data were within the normal clinical range for adult males. Although the Hb values were on the lower limit of the normal range, these findings supported the conclusions of Brotherhood et al. (1975) that the hematological status of male long-distance runners does not differ significantly from that of normal sedentary males. Significant negative linear trends ($P<.01$) from the IMM Hb and HCT values to the 8 H observations were observed in the NY Males. These results indicate a small degree of hemoconcentration immediately following the event, with a return to normal blood concentration within 8 hours.

Table 2 about here

The female subjects displayed slightly lower values for Hb, HCT, and RBCs

than the male subjects. Nevertheless, these values were within the normal clinical range for sedentary females. In the females, the IMM HCT and RBC values were higher than the 24 H values (but not higher then the control values). Again, the trend in Hb, HCT and RBC values supports the notion of a slight hemoconcentration immediately following the marathon run with recovery to normal blood concentration within 4-8 hours.

Total white blood cells (WBC) were significantly elevated following the races in all subject groups. Return to normal clinical values occurred sometime between the 8 H and 24 H samples (PHX MALES and FEMALES).

No significant differences were observed in mean cell volume (MCV), mean cellular hemoglobin (MCH), or mean corpuscular hemoglobin concentration (MCHC) in either the males or the females (Table 3). There were some changes in total serum protein values. In the PHX subjects, total protein was significantly elevated immediately (IMM) after the race. The females' values had returned to control levels (C) by the 4 hour (4H) sample, the males' values returned to control levels at the 8 hour (8H) sample.

Table 3 about here

The male control values for serum protein were higher than those reported previously for elite middle- and long-distance runners and cyclists, and slightly lower than those of sedentary males (Röcker et al. 1976). The albumin values of the subjects in this study were very similar to values previously reported for endurance athletes (Röcker et al. 1976), and also exactly in the middle of the normal clinical range. Therefore, we do not concur with Röcker et al. (1976) that endurance athletes have lower serum protein concentrations than sedentary individuals.

Serum Na^+, K^+, and Cl^- concentrations showed no significant changes

immediately following the marathon event (Table 4). This has also been reported by Viru and Korge (1971). Rose et al. 1970 studied 8 male runners 1 hour before and 1 minute after the 1969 Boston Marathon. They reported that serum protein increased 7.6%, and that serum Na^+ increased 4.3%. They concluded that the rise in Na^+ was the result of volume contraction. Since we found no changes in serum Na^+ with changes in total protein ranging from 7 to 14%, we do not concur that serum Na^+ varies with total protein. Further, we did not find statistically significant changes in serum K^+ following marathon participation as did Rose et al. (1970) and McKechnie et al. (1967).

Table 4 about here

Rose et al. (1970) reported a small (4%), but statistically significant rise in serum osmolality immediately following marathon competition. In the NY MALES, serum osmolality increased 16% immediately following the race, but the plasma osmolality of the PHX MALES and FEMALES showed no significant changes. It was our subjective opinion that the NY subjects sweat considerably more than the PHX subjects due to the greater course difficulty and higher environmental temperatures. Nevertheless, we are highly suspect of the exceedingly high mean IMM serum osmolality value obtained in the NY MALES. Considering the remarkably constant serum electrolyte values and plasma osmolality values (PHX MALES and FEMALES), we believe that the runners drank enough during and following the races to satisfy thirst, and thus kept osmotic pressure constant.

Changes in total protein or hematocrit values have been used to estimate plasma volume changes. However, red blood cells and plasma may not be uniformly distributed and protein may or may not move out of the bloodstream. If no change occurs in blood mixing, then variations in plasma volume can be estimated from changes in HCT values. If the amount of protein in plasma remains constant,

then changes in PV can be calculated from changes in plasma protein concentrations. Table 5 presents percentage changes in blood volume (BV), cell volume (CV), and plasma volume (PV) calculated from Hb and HCT values according to the method of Dill and Costill (1974) as well as percentage changes in plasma protein. Similar to the results of Dill and Costill (1974), we did not find that changes in protein concentration matched very well with ΔPV calculated from Hb and HCT. However, whereas Dill and Costill found that total protein concentration changes underestimated the ΔPV calculated from changes in Hb and HCT, we found the opposite. In other words, estimations of the degree of plasma volume contraction from serum protein values generally exceeded the indications of PV contraction utilizing Hb and HCT values. The discrepancies between the two methods of calculating the movement of water in and out of the vascular space points to the unreliability of one or both of the underlying assumptions. Nevertheless, it appeared that immediately following the races, the subjects were experiencing plasma volume contraction. If one places confidence in the calculations based on changes in Hb and HCT, then the subjects were essentially rehydrated 4 hours after the event. If one prefers the serum protein method, then the subjects were still not completely rehydrated at the 24 H mark.

Table 5 about here

Differential analysis was available in PHX and is presented in Table 6. Factors of importance in the observed leukocytosis were the changes demonstrated in the polymorphonuclear neutrophil (PMN) and lymphocyte contribution to the total WBC. Values in this table are % of total WBCs. These components varied inversely showing significant positive ($P<.05$) and negative ($P<.05$) quadratic trends, respectively. The marked increase in WBCs is probably related to two factors. Firstly, WBCs have a tendency to localize outside the axial stream

of blood along capillary walls. This is referred to as "margination." Increased blood flow has been shown to free these "bound" WBCs from the periphery and contribute to an observed increase in WBC count even when the actual number of cells has not changed.

Table 6 about here

A second mechanism possibly contributing to the leukocytosis may be an inflammatory response to tissue injury with inflammation, a significant shift in the differential towards a predominance of PMNs if often seen. The observed increase in PMNs outside the normal range following the race suggests that this mechanism may be the major factor in the observed leukocytosis.

The results of this study support the following conclusions:

1. Because body fluids shift from one compartment to another during and following a marathon race, considerable care must be taken in the interpretation of changes in blood borne biochemical indicators.

2. We seriously question the use of changes in total plasma protein values as an index of intravascular fluid volume following strenuous and prolonged exercise.

3. A definitive study of this problem is needed.

REFERENCES

1. Brotherhood, J., B. Brozovic and L.G.C. Pugh. Haematological status of middle- and long-distance runners. Clin. Sci. Mole. Med. 48:139-145, 1975.
2. Dill, D.B. and D.L. Costill. Calculation of percentage changes in volumes of blood, plasma, and red cells in dehydration. J. Appl. Physiol. 37:247-248, 1974.
3. McKechnie, J.K., W.P. Leary and S.M. Joubert. Some electrocardiographic and biochemical changes recorded in marathon runners. S. African Med. J. 41:722-725, 1967.
4. Röcker, L., K.A. Kirsch and H. Stoboy. Plasma volume, albumin, and globulin concentrations and their intravascular masses. Europ. J. Appl. Physiol. 36: 57-64, 1976.
5. Rose, L.I., D.R. Carroll, S.L. Lowe, E.W. Peterson and K.H. Cooper. Serum electrolyte changes after marathon running. J. Appl. Physiol. 29:449-451, 1970.
6. Viru, A. and P. Kõrge. Metabolic processes and adrenocortical activity during marathon races. Int. Z. angew. Physiol. 29:173-183, 1971.

TABLE 1

CHARACTERISTICS OF THE THREE SUBJECT GROUPS

		Hct, cm	Wgt, kg	% Body Fat	$\dot{V}O_2$ max, $ml \cdot kg^{-1} \cdot min^{-1}$
NY MALES	$\bar{x}$	175.6	71.6	----	----
	S.D.	±5.4	±5.0	----	----
PHX MALES	$\bar{x}$	179.5	70.1	7.3	58.4
	S.D.	±5.4	±5.8	±3.2	±5.0
PHX FEMALES	$\bar{x}$	166.6	52.0	11.4	59.2
	S.D.	±5.5	±8.4	±0.7	±7.1

TABLE 2

HEMATOLOGICAL CHANGES ELICITED BY MARATHON RUNNING

Variable	C	IMM	4H	8H	24H	P
NY MALES						
Hb(g)	14.2	15.3	14.8	14.4	----	NS
Hct(%)	44.1	44.9	42.9	41.8	----	NS
RBC(10^6)	5.0	5.1	5.0	4.8	----	NS
WBC(10^3)	6.0	15.3	14.8	11.2	----	C>IMM, 4H, 8H ** IMM>8H *
PHX MALES						
Hb	14.2	15.3	14.5	14.5	14.2	NS
Hct	41.0	44.8	42.2	42.3	41.9	NS
RBC	4.6	4.8	4.6	4.5	4.5	NS
WBC	4.9	16.5	13.2	13.2	7.7	C>IMM, 4H, 8H ** IMM>24H **
PHX FEMALES						
Hb	13.7	14.4	13.8	13.8	13.6	NS
Hct	41.1	42.9	40.8	41.0	40.0	IMM>24H **
RBC	4.3	4.5	4.3	4.3	4.2	IMM>24H *
WBC	5.1	14.0	13.5	11.0	7.4	C>IMM, 4H ** C<8H * IMM>24H ** 4H>24H **

** P<.01
* P<.05

TABLE 3

HEMATOLOGICAL CHANGES ELICITED BY MARATHON RUNNING

Variable	C	IMM	4H	8H	24H	P
NY MALES						
MCV(um^3)	88.9	87.9	87.0	87.6	----	NS
MCH(pg^3)	29.8	30.3	31.2	30.4	----	NS
MCHC(%)	32.8	34.5	34.9	34.7	----	NS
TOTAL PROTEIN (g/dl)	7.11	7.65	7.49	8.13	----	C<8H **
PHX MALES						
MCV	87.3	91.6	90.8	91.8	91.6	NS
MCH	30.0	30.9	30.6	31.0	30.8	NS
MCHC	34.6	34.8	34.8	34.8	34.3	NS
TOTAL	7.08	8.12	7.77	7.50	7.28	C<IMM, 4H ** IMM>3H, 24H **
PHX FEMALES						
MCV	94.0	94.0	93.0	93.5	93.0	NS
MCH	30.8	31.2	31.2	31.2	31.3	NS
MCHC	33.3	33.9	34.1	34.0	34.4	NS
TOTAL PROTEIN	6.82	7.72	7.32	7.30	7.15	C<IMM **

TABLE 4

SERUM ELECTROLYTES AND OSMOLALITY FOLLOWING A MARATHON

Variable	C	IMM	4H	8H	24H	P
NY MALES						
Na^+ (mEq/ℓ)	141.7	138.3	136.8	143.8	---	NS
K^+ (mEq/ℓ)	4.3	4.8	4.9	4.9	---	NS
Cl^- (mEq/ℓ)	102.6	98.0	91.4	99.0	---	NS
Osm. (mOsm/KgH_2O)	297	345	309	295	---	C<IMM*
PHX MALES						
Na^+	143.3	145.8	141.2	141.7	141.2	IMM>4H,8H,24H*
K^+	4.8	4.2	4.4	4.1	4.5	NS
Cl^-	98.8	99.2	96.5	97.0	98.7	NS
pl. Osm.	316	315	306	309	305	NS
PHX FEMALES						
Na^+	140.8	143.2	141.2	141.5	139.8	NS
K^+	4.5	4.6	4.4	4.3	4.4	NS
Cl^-	98.2	98.0	97.8	98.5	99.2	NS
pl. Osm.	312	320	318	316	308	IMM>24H**

TABLE 5

Percentage changes in volumes of blood, plasma and red cells following a marathon race

		Δ BV,%[1]	Δ CV,%[2]	Δ PV,%[3]	Δ total Protein,%[4]
Control → IMM	NY Males	-9.19	-5.95	-8.10	-7.66
	PHX Males	-7.19	+1.40	-12.76	-14.69
	PHX Females	-5.00	-0.84	-7.71	-13.20
Control → 4H	NY Males	-4.05	-6.68	-2.12	-5.34
	PHX Males	-2.07	+0.79	-3.76	-9.74
	PHX Females	-0.73	-1.44	-0.26	-7.33
Control → 8H	NY Males	-1.39	-6.54	+2.39	-14.34
	PHX Males	-2.07	+1.04	-4.09	-5.93
	PHX Females	+1.02	+0.78	+1.17	-4.84
Control → 24H	PHX Males	0	+2.18	-1.42	-2.82
	PHX Females	+0.51	-2.15	+2.25	-4.84

BV = Blood volume; CV = red cell volume; PV = plasma volume

1 = $\Delta BV,\% = 100\ (BV_A - BV_B)/BV_B$ (subscript B = before, A = after)

2 = $\Delta CV,\% = 100\ (CV_A - CV_B)/CV_B$

3 = $\Delta PV,\% = 100\ (PV_A - PV_B)/PV_B$

4 = Δ total Protein,% = 100 (total $Prot._B$ - total $Prot._A$)/total $Prot._B$

TABLE 6

DIFFERENTIAL ANALYSIS OF WBC COUNT FOLLOWING A MARATHON RACE

Variable	C	IMM	4H	8H	24H	P
PHX MALES						
PMN	63.6	81.0	79.8	70.0	60.0	C<IMM, 4H** IMM>8H* IMM>24H** 4H>24H**
LYMPH	33.2	16.2	14.8	24.0	31.0	C>IMM, 4H** IMM<24H* 4H<24H*
PHX FEMALES						
PMN	59.0	78.5	82.5	72.5	61.5	4H>C*
LYMPH	34.0	17.0	11.5	22.8	33.5	4H<C* 4H<24H*

PMN = polymorphonuclear neutrophil
LYMPH = lymphocyte
* $p<.05$
** $p<.01$
values are % of total WBC's